Comment on "Theoretical Model of a Purported Empirical Violation of the Predictions of Quantum Theory"

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Abstract

We show that an alternative quantum theory proposed by Stapp directly violates Einstein causality. This model was constructed to explain a single questionable experiment on paranormal psychic abilities in humans.

Our comment concerns the article by Henry P. Stapp, "Theoretical model of a purported empirical violation of the predictions of quantum theory" [1]. This paper develops a theoretical model of nonlinear quantum mechanics that is loosely based on work of Weinberg [2], and that turns out to violate Einstein causality, as we shall show below. It is clear that this article has been specifically created to explain the apparently anomalous results found in what is essentially a single, unreproduced, highly questionable experiment designed to establish the physical reality of paranormal phenomena. In particular, Stapp's reference 8 is to the telekinesis experiment of Schmidt [3], published in *the Journal of Parapsychology*. (Stapp actually participated in one phase of this experiment, a "sub-experiment" and co-authored an experimental report with Schmidt [3]; a fact that is not evident from Stapp's theory paper [1].) The conclusion of Schmidt—that Stapp is trying to model theoretically—is that the experimental test subjects are using their psychic powers to alter the laws of quantum mechanics and thereby modify the outcome of events that have already occurred in the past!

In the span of one minute we could construct at least 10 theories involving 10 separate modifications to the Schrödinger equation that would produce one or more of the following nonphysical effects: noncausality, nonlocality, energy non-conservation, nonunitary evolution of the wave function, and parity violation. In the absence of *overwhelming* experimental support that these effects indeed occur, such modifications do not constitute new physical theories but rather

mathematical exercises of little value. Should a theory that abandons Einstein causality be true, it would shatter the very foundations of physics as we know it. Such a modification to our basic physical laws should be made only if a vast body of repeatable experimental evidence requires us to do so. We shall argue below that the experiment of Schmidt does not provide this evidence. However, Stapp's model does indeed abandon causality, as we shall see.

The Schmidt article to which Stapp refers is not a report of a particular experiment, but rather of a meta-analysis of five sub-experiments, including one in which Stapp himself was involved [3]. Two of the sub-experiments included in the meta-analysis are unpublished and therefore have not been subjected to peer review.

It is important to understand the basic setup of these sub-experiments in order to comprehend the nature of the claims being made. These sub-experiments involve not only supposed psychokinesis (PK) — by which the putative mental influence of the subject can directly, by no known physical channel, influence matter — but a *retroactive* psychokinetic influence that supposedly operates backward in time. Although the five sub-experiments differ in some respects, a brief review of the first of them provides a feeling for the nature of the research.

In that first sub-experiment, Schmidt used a combination of Geiger counter and random number generator to generate a list of six-digit random numbers [4]. These numbers were employed in serial order, two at a time. Next, using an electronic noise random generator, Schmidt

produced a series of binary decisions, labeled "High" and "Low". Then he sent the list of seed numbers and the target assignments ("High" and "Low") to colleagues at Syracuse University, along with a program that was based on an algorithm that would use each seed number to produce some visual output on the computer screen. (He used three different programs to produce different visual displays, but one is enough to communicate the flavor.) The algorithm, starting with the seed number, generated a series of 0's and 1's, which were translated into the presentation on the monitor of a swinging pendulum, the amplitude of which was determined by the binary series.

So, the subject sat in front of the computer screen and the pendulum began to swing. If the target assignment was for High, he would attempt to increase the pendulum's amplitude; if it was for Low, he would attempt to reduce it. After a series of trials was completed, the subjects calculated the score for each trial (i.e., a number produced by the algorithm, based on the seed number, and corresponding to the amplitude of the pendulum). Each pair of seed numbers, then, generated, via the algorithm, a corresponding pair of outcome numbers, one with a target assignment of High and the other of Low. The difference between the score for the H number and the score for the L number provided the basic datum. These differences should average to zero since the seed numbers were randomly generated and the High-Low assignments were randomly generated.

The goal was to produce higher numbers for the High target assignments than for the Low target assignments. A small but statistically significantly difference from zero was found, indicating that the pairs of seed numbers had some correlation with the H-L assignments. Thus, two random processes were correlated. Schmidt and his co-authors were careful to avoid offering any particular theoretical interpretation of these results. However, in later papers, by Schmidt, and by Schmidt and Stapp [3], one of the explanations proffered for such effects is that of noncausality, whereby the mental effort of the subject retroactively affects the random events. According to this view then, the mental effort of the subjects would have reached back into the past, to the time when radioactive decay was producing events on a Geiger counter leading to the generation of six-digit seed numbers, which when taken in consecutive pairs, subsequently bore some relationship to each other — a relationship that was at that point yet to be specified by another random process, the electronic noise random generator.

Even more amazing, a task that no conscious brain would ever be able to carry out, was supposedly carried out unconsciously and automatically, across a continent (the subjects were in Syracuse; the number generators were in St. Antonio), and across time — to a particular time unknown to the subjects. Essentially, all the subjects needed to do was to "wish" and their wishes came true, to a significant, albeit small, degree. Note that this sub-experiment has never been successfully independently replicated. The other sub-experiments were of the same genre.

As far as we can tell from the research report, the empirical methodology does not by itself pose a problem — that is, there are no *obvious* problems. There are some minor weaknesses. For example, across his research history, Schmidt has often served as both subject and experimenter in a given study, and indeed, this was the case in some of the research under consideration here. This is not considered appropriate in orthodox psychological research, but neither does it automatically invalidate his data. However, given that there has been no replication in an independent laboratory, it is impossible to pronounce that the methodology was beyond reproach based only on the research report. Flaws and biases in "psi" research typically are not recognized as such by the researcher and therefore there is usually no evidence of them in the research report.

We are more concerned with regard to the apparent arbitrariness of the statistical analysis. Schmidt has used a particular method of meta-analysis that, while not incorrect, does raise questions as to why the particular method was chosen, and whether or not other methods would yield similar results. The standard method of meta-analysis is to begin by calculating an effect size and then to connect effect sizes to probabilities. Why this was not done is not clear.

We note that Schmidt employs a rather unorthodox way of breaking up the data into "individual units" within a sub-experiment. It is not clear just why this was done, or what the implications of this procedure are for the subsequent data analyses. In order to assess the propriety

of the data analysis in general and the meta-analysis in particular, it would be necessary to have access to the raw data.

Historically, the results of "successful" parapsychological findings have not held up — especially across independent laboratories and across generations. In orthodox fields of scientific inquiry, the standard practice is to withhold judgment until a novel finding — especially one that challenges prevailing theories — is independently replicated. The criterion of proof seems even more important when considering a claim that challenges one of the fundamental premises of modern science, namely Einstein causality.

Suffice it to say that no independent laboratory has replicated any of these sub-experiments. Given that, as Schmidt admits, most of the individual sub-experiments themselves failed to produce statistically significant results, the Schmidt data does not in any way confirm the existence of a psychokinetic effect. Thus, there is no basis for arguing that a violation of quantum mechanical theory has been demonstrated.

In the history of Schmidt's PK research, an acausal explanation of such experimental results has been offered. In particular, in the Schmidt and Stapp experimental paper, we find [3]:

> The results of [psycho-kinetic] experiments with pre-recorded random events appear most interesting and most puzzling because the subject's mental effort is made long after the random events to be affected have occurred. One tentative viewpoint [5,6] is that the subject's mental effort could act backwards to the time when the random events were generated and recorded. This would imply a non-

> causal mechanism in the sense that the effect (the biasing of the random events) occurs before the cause (the mental effort). it might be this element of noncausality that makes psychic phenomena so intuitively implausible and at odds with the known principles of physics.

It appears that in addition to this hypothesis, a second was eventually given—perhaps because such a blatantly acausal mechanism as outlined above is considered utterly implausible to most physicists as it is inconsistent with Einsteinian relativity. Hence, as a substitute, a second explanation was offered [7], *viz.* that the subjects bias the quantum-mechanical state reduction at the time when they exercise their mental powers. In this way, it is hoped, any violations of causality are avoided, simply because the subjects are not supposed to influence the radioactive decay months ago but only the state reduction that allegedly happens at the time of each of the PK sub-experiments. It is apparently on this second hypothesis that Stapp models in his paper [1].

There is much to be said about the fundamental misunderstanding of the quantum mechanical notion of state reduction inherent in this hypothesis. In particular, the far-fetched implicit assumption is simply preposterous, namely, that one has a coherent entangled wave function for the complete system of: radioactive sample, Geiger counters, monitoring PC, floppy disk drive, floppy disk, printer, print-out, United States Postal Service, plus anything else that has been interacting with any one of the components in the time between the clicks of the Geiger counter and the actual PK experiment. Consider—even in the best EPR-type experiments it is *extremely*

difficult to get *microscopic*, entangled quantum states of matter that extend just across a lab bench for a few microseconds.

We shall finish our comment by pointing out that Stapp's theoretical model of Schmidt's bizarre experiment is intrinsically self-contradicting. Stapp's model is technically based upon the nonlinear extension of quantum mechanics studied by Weinberg [2,8], but really the nonlinearities of Weinberg's type are not essential. One can "revert to a linear theory," as does Stapp [1]. What is essential is a non-Hermitian piece of the Hamiltonian which gives rise to a nonunitary evolution.

At first sight, the avoidance of Weinbergian nonlinearities takes care of Gisin's objection [9] who observed that nonlinearities of any kind in the Schrödinger equation *always* enable one to construct a mechanism for sending messages faster than the speed of light. And as soon as this is possible, acausal actions backwards in time are possible as well [10]. Incidentally, the note at the end of reference 8 clearly indicates that Weinberg himself considers such a state of affairs unacceptable.

A second look however, reveals that Stapp's proposal of a linear, yet non-Hermitian evolution is just as acausal as is the nonlinear, Hermitian one. The reason is the necessary normalization of the state vector to unit length, needed for the correct computation of expectation values or probabilities. The complete process of (i) a linear, non-Hermitian evolution, followed by (ii) the normalization of the state vector, is a nonlinear mapping (not necessarily of the kind considered by

Weinberg) of the initial state vector on the final one. Consequently, Gisin's arguments about nonlinear quantal evolutions apply, and Stapp's model is recognized to be unavoidably acausal. Therefore, Stapp was not successful in his attempt at constructing a working model for Schmidt's hypothesis of an explicitly *causal* mechanism that biases the state reduction. In short, Stapp's model is just as inconsistent with Einsteinian relativity as was Schmidt's original and untenable hypothesis [3,5,6].

In conclusion, the model proposed by Stapp is manifestly inconsistent with the known physical law of Einstein causality. As such, it should be taken seriously only if it explains an overwhelming body of incontrovertible experimental evidence indicating that such violation of physical law actually occurs. As we have pointed out above, the single experiment that seems to indicate this violation, is extraordinarily "underwhelming", and we conjecture that it will be unrepeatable by any independent experimental group.

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